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ABSTRACT

This unit is a part of a series of materials produced by a project to develop locally applicable class, lab, and field materials in ecology and social studies for Guam junior and senior high school. While the materials were designed for Guam, they can be adapted to other localities. This unit is designed to interest the student in growing plants for home use. The publication includes sections on: (1) plant nursery; (2) backyard gardening; (3) backyard crops; (4) hydroponics; and (5) plant reproduction. Both background material and activities are included. (RH)

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Life On Guam Farm & Garden

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by Philip H. Moore

art Lita Payne

SE 021 730

Figure 1 This is what it's all about!

Life On Guam Farm & Garden

by Philip H. Moore

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design Jane Grobins

Life On Guam

...a project to produce locally applicable class, lab, and field materials in ecology and social studies for Guam junior and senior high schools. This project is funded by a grant under ESEA Title III, U. S. Office of Education - Department of Health, Education and Welfare——whose position, policy, or endorsement is not necessarily reflected by the content herein.

".....to ultimately graduate citizens who are knowledgeable and conscientious about environmental concerns of Guam and the rest of the World."

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I. Introduction

This unit, Farm and Garden, we hope will interest you in growing plants for home use. Home grown plants can beautify the home as well as provide food for the family.

In the past, before Japanese times and World War II, the people of Guam raised their own food and lived happily within their own villages. After the war many people were separated from their lands, fields were in ruin and livestock was lost or scattered. Many people were forced to take jobs with either the armed forces or the Government of Guam. Others tried to go back to the old way of life; some of these were lucky but many failed, and life in the villages changed very fast. It was easier to feed the family by taking a job. The stores were full of things to buy that the old way of life could not provide.

Another blow to the old ways was typhoon Karen which ruined crops and blew houses away. After this storm, in November 1962, many farmers who had lived through the war were discouraged and

Figure 2 From this.....to this.

they too decided that a steady job could give their families more than farming could.

So the people have turned away from the land and toward a new way of life on Guam. This does not mean that no farming is done today; just the opposite, you have only to visit the Farmers' Market and the many roadside stands to realize that a lot of crops are still being raised. In most cases, however, farming is not the only means of income for the people working at these places.

While the present cost of living goes higher almost daily, it would seem a good idea for each

family to raise at least part of their own food. This can be a fun thing to do and at the same time help to reduce the cost of feeding a family.

Minigardening

Most of us don't have farms but a few vegetables can be grown in very little space, a 'minigarden', if a few simple directions are followed. The U.S. Department of Agriculture Home and Garden Bulletin #163 called "Minigardens for Vegetables" gives the details you need for growing in a small space enough vegetables to supply a family. Also the Cooperative Extension Service of our own University is issuing a series of publications useful to farmers. Circular No. 1 in the series is "Vegetable Minigardens".

Synthetic (man-made) soil is suggested for minigardens because it contains a complete food supply, holds water and provides a place in which plants can take root and grow. Most anything can be used as a pot in which one or more plants can be grown. For drainage, holes should be cut in the bottom of each pot. Cover the holes with small stones to keep the soil from washing out. For good growth give the plants plenty of room to spread out.

Suggested Activities:

1. a. Take a trip to the Department of Agriculture and find out which local plants might grow in this type of garden.

   b. Find out if the things you need can be bought in Guam, if not, where they can be found.

   c. Find containers for holding the soil: baskets, pails, boxes, plastic bags, etc.

   d. Follow directions in Bulletin #163 and Circular #1 and grow several kinds of plants in school nursery or lath house.

2. Each student take a bag of synthetic soil home and grow one or two kinds of plants as a home

project. When plants are fully grown bring in a sample of your produce to show the class.

3. Make a trip to the hydroponics set-up at Hawaiian Rock, or other. This should give you ideas about spacing of plants, proper light, feeding, watering and support for the plants while they're growing.

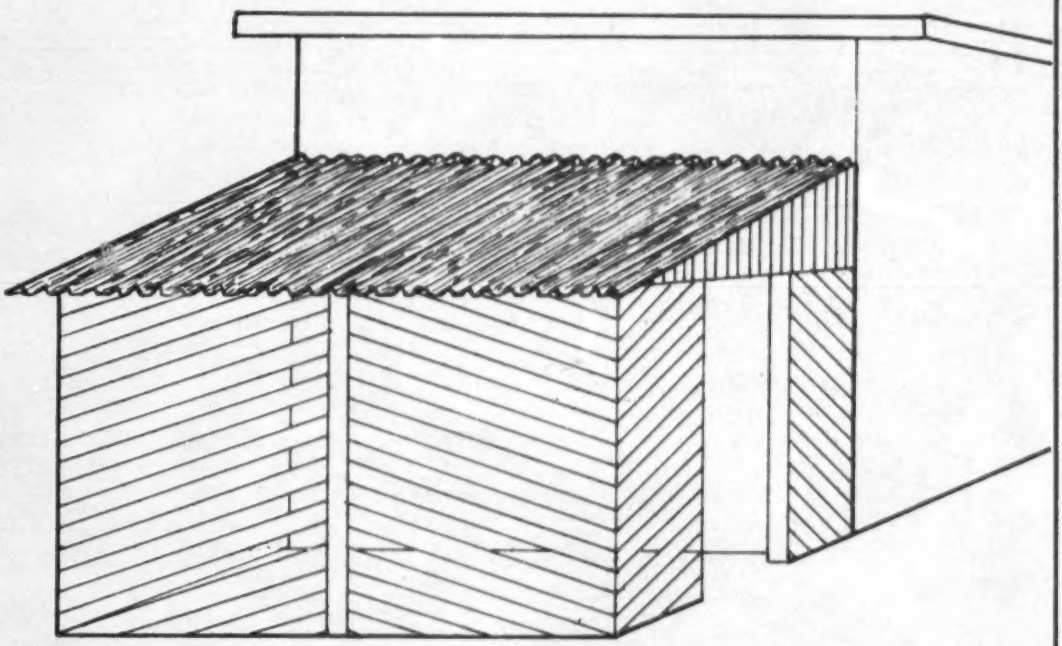

Figure 3 One kind of lath house.

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II. Plant Nursery

With the use of seed flats and small plant containers, the gardener can provide himself with many advantages. One of these is having a sure supply of plants when he needs them. This is a cheaper than buying seedlings and it helps to build an interest in the garden and its preparation.

Not all plants need to be started in seed flats. Cucumbers, melons, pumpkins, squash, beans and similar fast-growing plants generally suffer a setback from transplanting. With careful soil preparation, seeds of these plants can be sowed directly into individual small cans—that will confine the root system as it develops. When ready for the field the containers should be carefully removed so as not to break up the soil-root unit. In this way the plants have the size and root system development to get them off to a good start in the ground.

Getting Started:

Other factors such as temperature, moisture, carbon dioxide, and oxygen are needed for the successful germination of any seed. Even though the temperature is ideal and moisture perfect, if the oxygen supply is too low or carbon dioxide is too great, poor germination will follow. For best results, these four factors must be at their best. A fifth factor, viability, should not be overlooked. This means the ability of a seed to live. Samples from most seed batches must be officially tested for viability before the seeds are sold on the market.

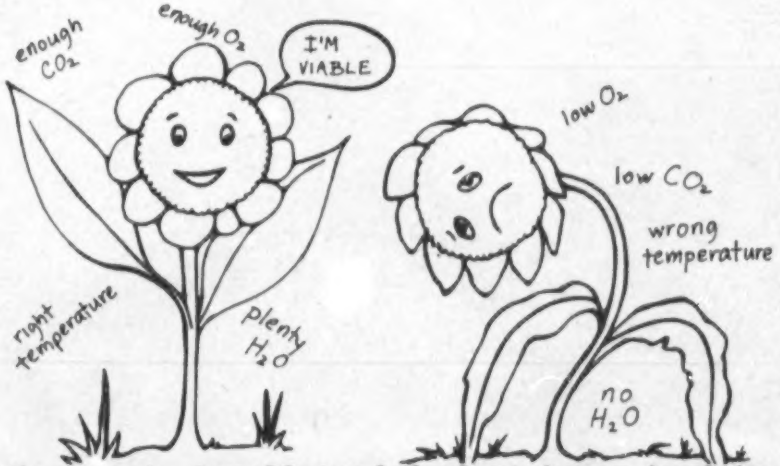


Figure 4 A well-tended plant keeps healthy.

Soil Preparation:

The best soil for seed-flat planting is one developed ahead of time from a compost pile. (See section on Composting, pages 10ff.). Compost material combined with sand makes an excellent soil. If compost is not available, a good rich loam soil mixed with sand is an easily available soil mix. The following should be carefully considered for best results.

1) A desirable soil is one that will easily crumble when dry, and will not form a crust over the seeds. If a crust forms, the seedling may not be able to reach the surface.

2) Soil must have enough well-decomposed organic matter so that it does not dry out too fast.

3) The soil must be fine enough to make close contact with seeds and moisture, yet provide them with good aeration.

Plant food or fertilizers should never be added directly to the soil in these flats before sowing the seeds. A too-fertile soil may make the stem grow too fast for the roots.

Soil Disinfection:

Clean, disease-free seed should never be planted in soil that may contain disease organisms. The only sure way to have disease- and insect-free soil is to disinfect it.

There are a number of methods of disinfecting soil. Among them are steam, hot ovens (on a small scale), electric soil heaters, formaldehyde and regular household clorax. Clorox is fairly cheap and very effective if diluted to one part clorox in five parts of water. Commercially prepared fumigants are also availabe on the Island and information can be obtained through the Agriculture Extension Service, University of Guam.

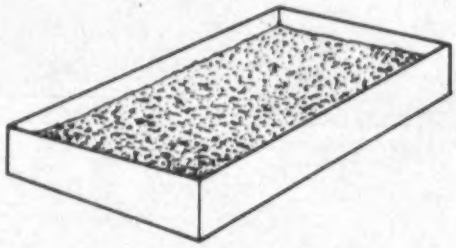
Seed Flats:

Flats are shallow wooden boxes 5-10 cm deep and of a size that is easy to handle, such as 45-60 cm. This size allows for easy movement into and out of

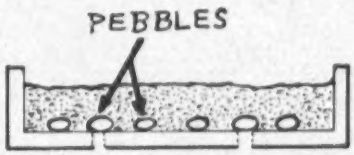
the sunlight and for carrying into the field for planting. Possible damage to young roots is avoided by reducing the time between removal from the flat and planting.

After washing the flats, it is always a good practice to disinfect them with formalin or boiling water before re-use.

Figure 5 Seed flat.



Cutaway view showing drainage holes covered with pebbles.



Filling the Flats:

The bottom portion of the flat should be covered with coarse materials such as pebbles to provide drainage. On top of this is placed the soil mixture—to about 1 cm from the top. A small block of wood can be used to press down the soil firmly to stop it from drying out. This also provides good soil particle contact for easy upward movement of moisture. Enough fine soil is then sifted through 0.5 cm wire mesh screen to fill the flat. Level and re-firm the soil and the flat is ready for sowing of seeds.

Sowing the Seeds:

After filling and firming the soil in the flats, mark out rows for seeds using a thin strip of board held edgewise. Sow the seeds thinly, as a heavy seeding will produce spindly, weak plants that are difficult to transplant. Mark all rows carefully and plant only varieties of seeds with similar germination times in the same flat. (These times are printed on the packages.) Plant small seeds about 0.5 cm deep. Larger seeds are planted slightly deeper. Soil used to cover the seeds should be of the same material that is used for the top of the flat. Seeds sprout best in darkness, and newspaper placed over the flat

will provide this. The paper must be removed, however, as soon as the seedlings break through the surface of the soil.

Flats should be watered soon after seeding. The most uniform way to water a flat is to place it in a container large enough to allow it to sit in 2-3 cm of water. The moisture will move by capillary action (creeping bit by bit through the soil) very quickly up to the surface and around the seeds. When this happens, take the flat out of the water and allow to drain.

Transplanting:

Plants started in seed flats are usually transplanted into pots at least one or more times. Such plants as tomatoes may be transplanted several times between the seed-flat stage and actual field setting.

With practice, transplanting becomes quite simple and quick. Most transplanters make simple spotting boards to speed up the job. These boards will help to keep the rows straight and neat and give each plant an equal growing space.

A spotting board consists of many small pegs equally spaced on a board the size of the flat. When the small seedlings are placed in the holes made by the pegs, the soil should be pressed firmly against the roots to insure good soil-root contact. Seedlings are generally set a little bit deeper than they were grown in the previous container.

For tomatoes, eggplants, peppers and similar plants, small biodegradable (decomposable) containers such as paper cups and milk cartons, etc.,

Figure 6 Spotting board with dibblers.

can be used with one plant to each. For best results, cut holes or completely remove the bottom of the container before placing in the ground. The major advantage of such containers is that they can be placed directly in the ground with the seedlings in them; thus the roots are not disturbed.

The first transplanting should be made when the first true leaves are fairly well developed. Watering the transplants after setting helps to settle the soil around the roots. When small seedlings or tender plants are transplanted they should be shaded for a few days. This can be done by placing palm fronds over the plant during the hottest time of the day.

Hardening Plants:

When plants reach the age and size for field transplanting, it is usually a good practice to "harden off" the plants to help them adjust to the heat, wind, and drying out of field conditions. Generally, a well-hardened plant is darker green than a non-hardened one.

The easiest and most successful way to bring about hardening is to withhold water, or in other words, keep the plant drier than usual for a period of several days to nearly a week before transplanting.

Field Planting:

The plant flats should be well-watered before being taken out to set in the field or garden. This watering should be done the day before setting so that all excess water has had time to drain away, leaving reasonably firm but moist soil around the roots.

To help establish new transplants with a minimum of setback the following should be practiced.

a. Dig a hole deep enough and wide enough so that the plant has plenty of room.

b. Fill in with some of the topsoil around the roots and firm carefully and lightly to remove air pockets.

c. Use a bit of water (a cup to several cups) after the plant is placed, but before the hole is closed. This is to puddle the soil about the roots for better soil-root contact and to remove any air pockets.

(Sometimes commercial starting solutions are used instead of plain water.)

d. Close the hole completely, again using some of the better topsoil. Except for woody plants, do not prune plant parts on transplanting. Pruning the leaves will remove the plant parts used to manufacture carbohydrates necessary for growth. Root pruning is even less desirable because transplanting generally causes some root damage under the most careful conditions.

Conclusions:

Carefully grown, healthy plants are needed for successful crop production. A young plant should have a strong stem and root and be free of disease.

The use of seed flats and transplant cartons, cans, etc. gives a grower the following advantages:

1. More time in which to prepare the soil for field planting.
2. Protection against snails and insect diseases while plants are in the seedling stage.
3. Easier weed control.
4. The chance to grow other crops while future trans plants are growing in the flats.
5. A saving on costly seed, because the excess or thinned plants can be saved and become healthy transplants.
6. Provides the grower with plants of the variety he wishes and at the time he wants them.
7. Easy removal of weak or sickly plants without loss of field space.
8. Easier and cheaper watering.
9. Easier protection from bad weather.

10. Plants can be started well before the field soil is ready. In this way the grower gets a running start on the early, usually high-priced market.

11. The expense of insect and disease protection is less than in the field. The dusts and sprays are concentrated directly on the plants themselves so there is very little waste.

Suggested Activities for Students:

1. Take a look at the nursery at the Guam Department of Agriculture. Note the overhead irrigation system, the kinds of soil used, and their growing methods.

2. Make a list of plants that should be started in the nursery in order to get a good start in life.

3. Look for some farming magazines where you will find samples of well-kept nurseries. Talk over with other members of the class the possibility of putting up a school nursery.

4. Invite a representative from the Department of Agriculture to talk and show the class techniques of potting and transplanting.

Compost for Guam Gardens:

"Compost" refers to a decomposed mixture of plant materials with animal manures or commercial fertilizers and moisture. This mixture is usable as plant food to improve rooting and in general to increase the growth of plants.

Any combination of materials may be used, such as grass, wood, small branches, leaves, paper, straw, etc. These can be used together with animal or poultry manures or with commercial fertilizers. Properly handled, even the family garbage can be used in a compost pile.

A compost made from plant and animal material also contains the minor elements used by plants. Decomposed plant materials contain at least a small amount of each element necessary for plant growth. Any further additions of complete fertilizers will help in the production of bigger and better plants than is possible without them.

Many people try to judge the richness of soil by its color. This is not a good method because of the many variables involved. A soil should be loose, high in organic matter, and easy to cultivate. It should also have good depth and contain the necessary nutrients for maximum plant growth. A compost properly made can do much to make a poor or ordinary soil into a good fertile soil. Soils are generally dead without humus, which is exactly what a compost pile is made of.

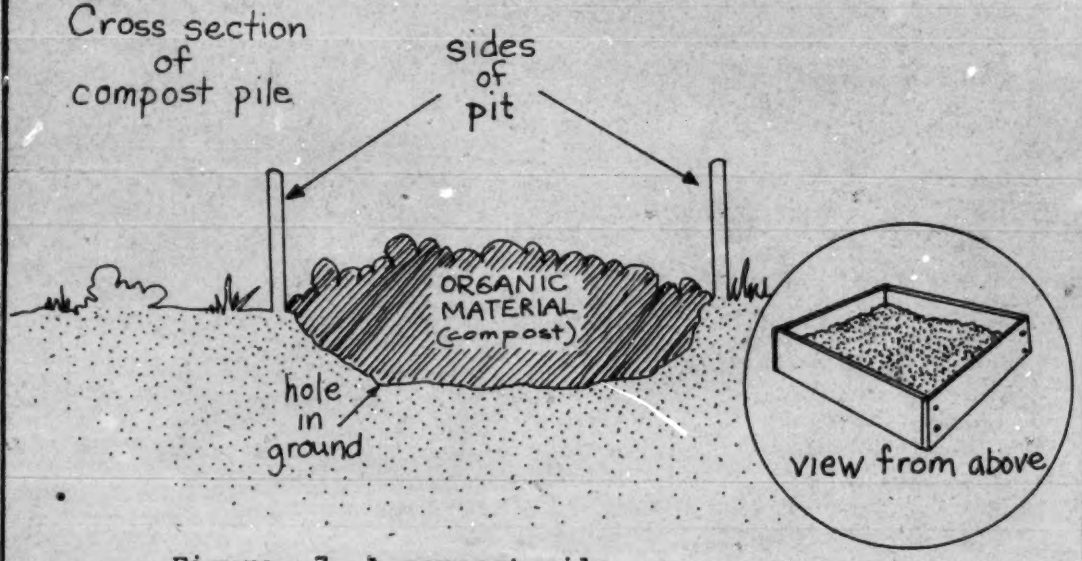


Figure 7 A compost pile.

There is no exact way to make a good compost. Much depends upon what materials are used, in what quantities, and how they are handled:

1. Dig a shallow hole 25-35 cm or so deep and about 2 meters square. For the sides, construct a small pen or framework. Used corrugated metal roofing, wood planks, boards, or even soil will serve the purpose.

2. Throw into this area any or all of the types of material mentioned above.

3. Add the materials in layers spread evenly about 20 cm deep. The center of the pile should be low to catch and hold all available moisture. This moisture is very necessary...See how one compost scientist did it:

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In George Washington's time, garbage was not the problem it is today. There were fewer people. Food did not come in cans. Paper was not as widely used as it is today. Bottles were not discarded. Plastic did not exist. Much more space was available where things could be thrown away, and left to rot. But more than that, people lived differently then. Their way of life is described by this New England adage:

Eat it up. Wear it out. Make it do. Do without.

Nevertheless, those early Americans made compost, usually with animal manures and some other kinds of organic matter, mostly for agricultural use. The end product was applied to the soil in an effort to increase crop yields.

George Washington experimented with composting in this way, and if he were alive today, he'd be an organic farmer and a staunch advocate of composting!

One thing he was very interested in was building up and conserving the fertility of the soil. This is clearly revealed in the book, "George Washington, Farmer", written by Paul L. Haworth in 1915.

After the Revolutionary War ended, one of the Washington's main concerns was the restoration of the land on his plantation. For this purpose, he wanted to hire a farm manager, but one with very special qualifications. Washington wrote that the kind of man he was looking for had to be "above all, like Midas, one who can convert everything he touches into manure, as the first transmutation toward gold; in a word, one who can bring wornout and gullied lands into good tilth in the shortest time."

According to Haworth, Washington "saved manure as if it were already so much gold, and hoped with its use and with judicious rotation of crops to accomplish" that. In 1794, Washington himself wrote that, "Unless some such practice as this prevails, my fields will be growing worse and worse every year, until the crops will not defray the expense of the culture of them".

Washington's concern with composting is revealed by an experiment which he recorded in his diary on April 14, 1760. Here is the report in his own words:

"Mixed my compost in a box with the apartments in the following manner, viz.

"No. 1 is three pecks of earth brought from below the hill out of the 45-acre field without any mixture.

"No. 2 is two pecks of sand earth and one of marle (clay and calcium carbonate) taken out of the said field, which marle seemed a little inclined to sand.

"3 has two pecks of sand earth and one of river sand

"4 has a peck of horse dung.

"5 has mud taken out of the creek.

"6 has cow dung.

"7 has marle from the gulleys on the hillside, which seemed to be purer than the other.

"8 sheep dung.

"9 black mould from the gulleys on the hillside, which seemed to be purer than the other.

"10 clay got just below the garden.

"All mixed with the same quantity and sort of earth in the most effective manner by reducing the whole to a tolerable degree of fineness and rubbing them well together on a cloth. In each of these divisions were planted three grains of wheat, 3 of oats, and as many of barley, all of equal distances in rows and of equal depth done by a machine made for the purpose. The wheat rows are next the numbered side, the oats in the middle, and the barley on the side next the upper part of the garden. Two or three hours after sowing in this manner, and about an hour before sunset I watered them all equally alike with water that had been standing in a tub about two hours exposed to the sun."

Washington kept this experiment going for three weeks. He then concluded that Nos. 8 and 9 gave the best results.

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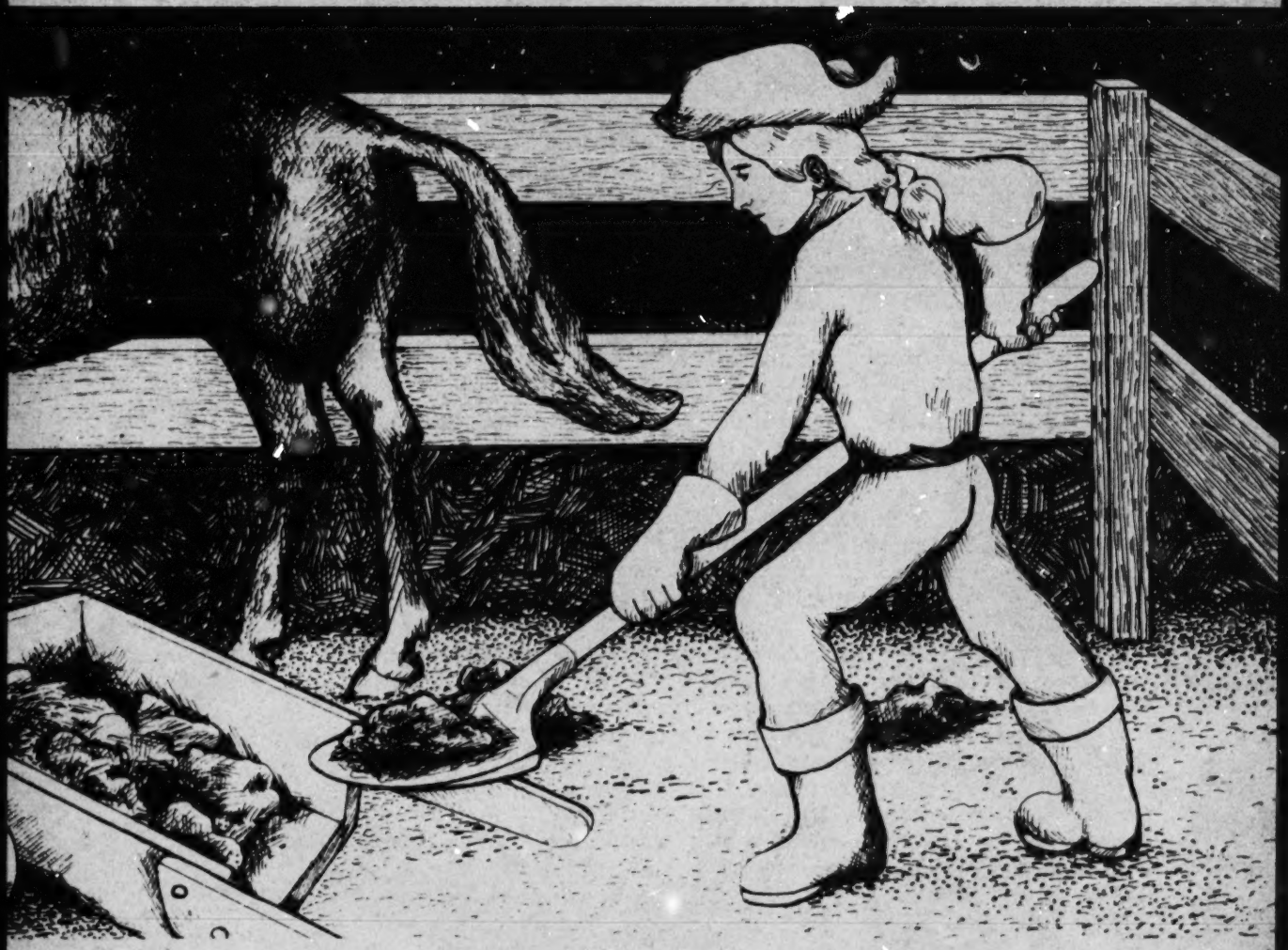

Figure 8 George Washington was a great re-cycler.

III. Backyard Gardening

1. Selecting a Good Garden Location:

If the house owner can choose a site for his garden, he should select one that—

a. Is near the house for easy access and protection.

b. Is close to a source of water.

c. Is away from large trees, shrubs, and hedges. The roots of these plants will deprive your garden plants of water and nutrients.

d. Is well protected from strong winds.

e. Has a good amount of soil that is high in organic matter and plant food necessary for growth.

Guam soils have the same basic elements contained in soil elsewhere. However, the proportions of nitrogen (N) phosphorus (P) and potassium (K) vary from place to place. The differences can be noted by experimentation and chemical analysis of soils.

The physical part of soil is made up of small particles of rock or mineral matter. By a decaying process, roots, leaves, and stems are added. Animals such as insects, birds, and countless others die in the soil or on its surface. The total of these decaying remains are part of the soil and are called humus. Soil formation goes on as rocks are broken down by weathering. Such agents as wind, water, heating and cooling, chemical action and the action of animals and plants are responsible for this breakdown.

There are three main types of soil that vary in composition and texture depending upon the size of the rock particles:

a. Soils containing hard, coarse particles are called sandy soils.

b. Soils composed of much finer particles are called clay soils.

c. Soils having a mixture of sand and clay are called loamy soils.

If the soil mixture is mostly clay, it is said to be clayey loam. If the mixture is mostly fine sand, it is sandy loam.

Large amounts of humus in loamy soils enable plants to obtain minerals. Humus is located in the top layer of the soil and is usually dark-colored.

Below the topsoil is the subsoil. It is light-colored because it has been undisturbed by cultivation.

Beneath the subsoil are the parent materials, which break up into smaller and smaller pieces and eventually become soil. When soil is prepared for planting, care must be taken not to mix the subsoil with the topsoil. To avoid this, cultivation should reach only to the depth of the topsoil.

Don't mix subsoil with topsoil!

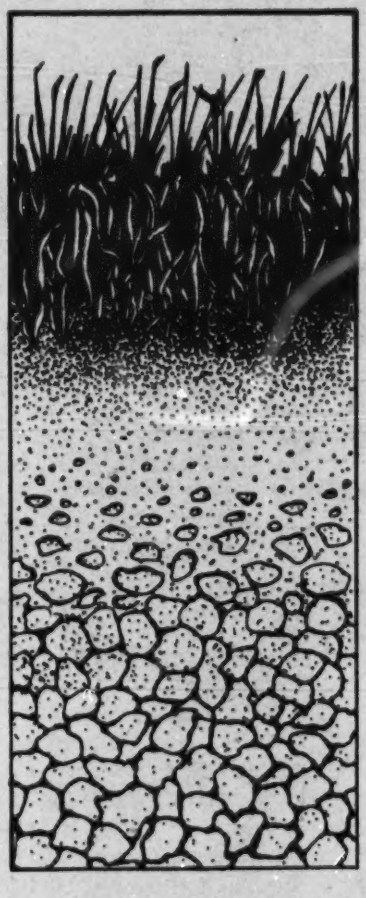

Figure 9 Soil Profile

2. Preparing the Soil for Planting

It is very important that the soil should be well-loosened so that when seeds are planted they have all the necessary things for germination such as warmth, air, and moisture. A well-loosened seedbed has the following advantages:

1. Plant roots, in search for minerals, can push through the soil easily.

2. Water is readily taken up by the plant.

3. Air circulation is good.

3. Backyard Gardening Suggested Activities

1. Draw a plan for your backyard garden.

2. Make a list of plants you would like to have in your garden.

3. Ask at the Guam Department of Agriculture or the Farmers' Market about seeds, fertilizers, and insecticides that can be bought on the Island.

4. Look for a planting timetable at the Department of Agriculture and try to follow it as closely as possible.

5. Make a plan, using the school garden plot, for a family garden and keep careful records of production.

6. Figure out the value of the produce in terms of average family budget.

IV. Backyard Crops

A few backyard garden crops are suggested below. If insect damage or any unusual growth of leaves or stems is noticed, an agent of the Department of Agriculture can help you.

Tomatoes, Peppers and Eggplant:

Plants should be started in flats with seeds planted 2-3 cm apart and about 5 cm between rows. These can be transplanted in the field as soon as they develop the second set of leaves and reacha height of 10-12 cm.

All of these plants do best in good fertile soil. The addition of humus in the form of peat moss, leaf mold, coconut fibers, grass cuttings, straw, etc., will help to hold moisture and minerals that have been added to the soil in the form of commercial fertilizers.

For best results, tomatoes and eggplants should be staked (tied up); this is done to prevent the fruit (edible part) from coming in contact with the soil.

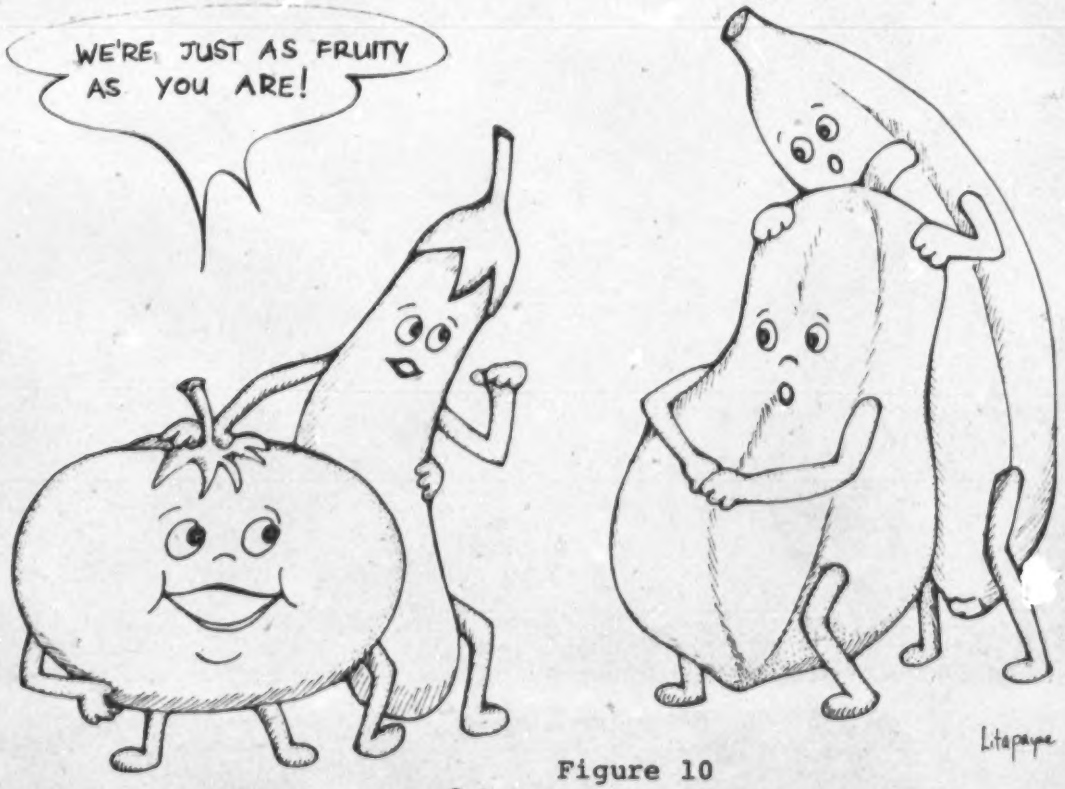

Figure 10

Several varieties of each of these plants are available on the Island. Up-to-date information about their culture is available at the Department of Agriculture.

Corn

Corn should be planted on the best-drained and most fertile soil on the farm. The seed can be planted in rows or in hills (mounds) with 3-5 seeds to a hill. The hills should be a meter apart in the rows. This can vary depending on the method of cultivation to be used. The germination time (time required for seeds to sprout) is less if the seed is soaked in water for a few hours. Weed control is important until the corn plants are well-established.

Salad or Leafy Crops

Chinese cabbage, Swiss chard, endive, kale, lettuce and mustard greens are leafy crops that can be easily grown in backyard gardens.

These plants can be started in flats or directly in the field. If planted in the field, a good supply of tender salad material can be ready for use in a short time as the plants are thinned to proper spacing. 15-25 cm should be allowed between plants and 45-50 cm between rows.

Fast-growing crops like these respond well to additional nitrogen. This can be given to plants in the form of commercial fertilizers or well-rotted barnyard manure. This should be placed 10-12 cm from the plant as a side dressing.

Lettuce is not well-suited to Guam. It may be grown during the dry season, however, if kept in germinating flats for about 4 weeks before planting in the field. Too much rain will rot the head before maturity. Leaf lettuce does not form a head. It is most successful and may be grown anytime of year. It can be sown directly in the field and later thinned to 10 cm apart. As mentioned above, the thinned plants can be used in salads so no seed is really wasted.

Mustard greens can provide a lot of leaves for cooking. They should be grown only in the dry

season. They grow best in rich moist soil and can be treated in the same way as lettuce.

Cucumbers, Melons and Other Vining Crops

It is best to plant these in hills with 3-5 seeds to a hill. Vine crops need plenty of space——at least 1.3 m between hills and about 1.5 m between rows.

The addition of well-rotted chicken or other barnyard manure under each hill is a good practice. The manure should be placed 10-15 cm below the surface of the ground and covered with 15-20 cm of soil. The seeds can then be planted with no danger of burning the roots when they start growing. Clean cultivation is best and at least weekly hoeing until the plants are well underway.

Beans

Beans can be grown anytime of year on most any kind of soil as long as it's well-drained. The soils of southern Guam are not as well-suited to beans as the northern soils.

Pole beans (climbers) should be planted in hills 45-60 cm apart with 1.2 m between rows.
Plant 5-7 seeds to a hill at a depth of 5 cm.
When seedlings emerge they should be thinned to the strongest three. Pole beans should be staked.

Bush beans are sown in rows with seeds 8 cm apart, later thinned to 15 cm apart. Distance between rows should be about 1.5 m.

A handful of complete fertilizer under each hill or sprinkled lightly in rows helps to get the plants off to a good start. Side dressings after about the first month and after the first picking help extend production of beans.

V. Hydroponics

Hydroponics is the culture of plants in water. All of the nutrients (minerals) necessary for growth are supplied by chemicals that are added to the water. The plant roots are held in a growing medium (sand, peat, gravel, etc.). For moisture, water is either flushed to the surface from below or sprinkled on from above. Water does not stand (stay) in the growing medium but the medium is kept wet so that mineral salts can be taken up readily by the roots. Ready-mixed nutrient (Hyponex is one kind) is available on the Island at P.C.C. and perhaps elsewhere. Complete instructions for use are printed on the box and should be followed carefully.

It has been said that hydroponics will someday feed the World. This statement may very well come true when we think about the rate at which farm land is being used for building houses, highways and factories. Today, in many areas, cattle feeds such as hay, alfalfa, oats and barley are being grown hydroponically. Universities are offering courses in hydroponics and are training people to provide help for areas at home and in other countries.

Guam at present (late 1975) has several highly productive hydroponics plants. One of these is at Hawaiian Rock and another is Guam Service and Development Corporation near the Latte Heights Estates. These are money-making businesses and were very expensive to build. A small hydroponics set-up however can be made without too much expense. Enough scrap lumber can generally be found to build a framework that will support a plastic roof with a screen or chicken wire siding. Depending on where you are, the windward side may also need protection with plastic siding. The roof should be high enough to allow tomato plants or vine crops to grow to their full height of 3-4 meters. The roof shelters the plants from rain so that the pollen stays dry and pollination is completed. The chicken wire or screen keeps out snails and the neighbor's chickens and children.

Most garden plants can be grown in large enough numbers to support the needs of a family in a very small space. The growing room for garden plants can be cut in half. In other words twice as much can be grown in the small space as could be grown in soil. Plants such as tomatoes or any of the vining crops should be tied up with string from a framework above. This confines each plant to a relatively small space.

The growing medium can be anything from crushed rock to styrofoam. On Guam, however, the "easiest to get" materials—beach sand and crushed coral—have not proven satisfactory. The limestone breaks down and this causes an alkaline condition that is hard to adjust. If limestone is used it should be changed after each crop, and acid should be added to correct the alkaline-acid balance. The best medium is any non-active material that is easy to find. Well-rotted coconut husks that break or crumble into small chunks could be used successfully. Styrofoam packing or the cork sheets from old refrigerator trucks make excellent growing medium when broken into small pieces. Vermiculite and peat moss have been used also and proved to be very successful.

Any container can be used for hydroponics as long as it will drain fast. Beds can be constructed of wood or cement. Good containers can be made from 55-gallon drums cut in half lengthwise and welded end to end (two make a convenient length). The beds should be raised and slightly sloping so the nutrients can drain out and be returned to a storage tank after each wetting (See Figure 11). A family-sized hydroponics plant can be as elaborate or simple as the grower wants. An automatic sprinkler system with storage tanks and electric pumps can be used. If a simpler system is wanted, the nutrient can be poured over the medium with a sprinkling can and be caught in a pail as it drains out. A good, but simple, way would be to use a raised tank so the nutrient will drain through a hose by gravity flow. The water can be collected again and returned to the tank.

Seeds can be germinated right in the hydroponics tank or can be started in flats and later transplanted into the tank. The easiest way is to sow the seeds in 5 cm fiber pots that can be bought in any garden supply store. When the seedlings are ready to transplant, the pots with the started plants in them can be placed in the growing medium. When this is done, the shock of regular transplanting is much less. Two or three seeds should be sowed in each pot to make sure at least one germinates. They can later be thinned to the strongest seedling.

Most garden plants adapt well to this type of culture. Some tall plants need to be supported

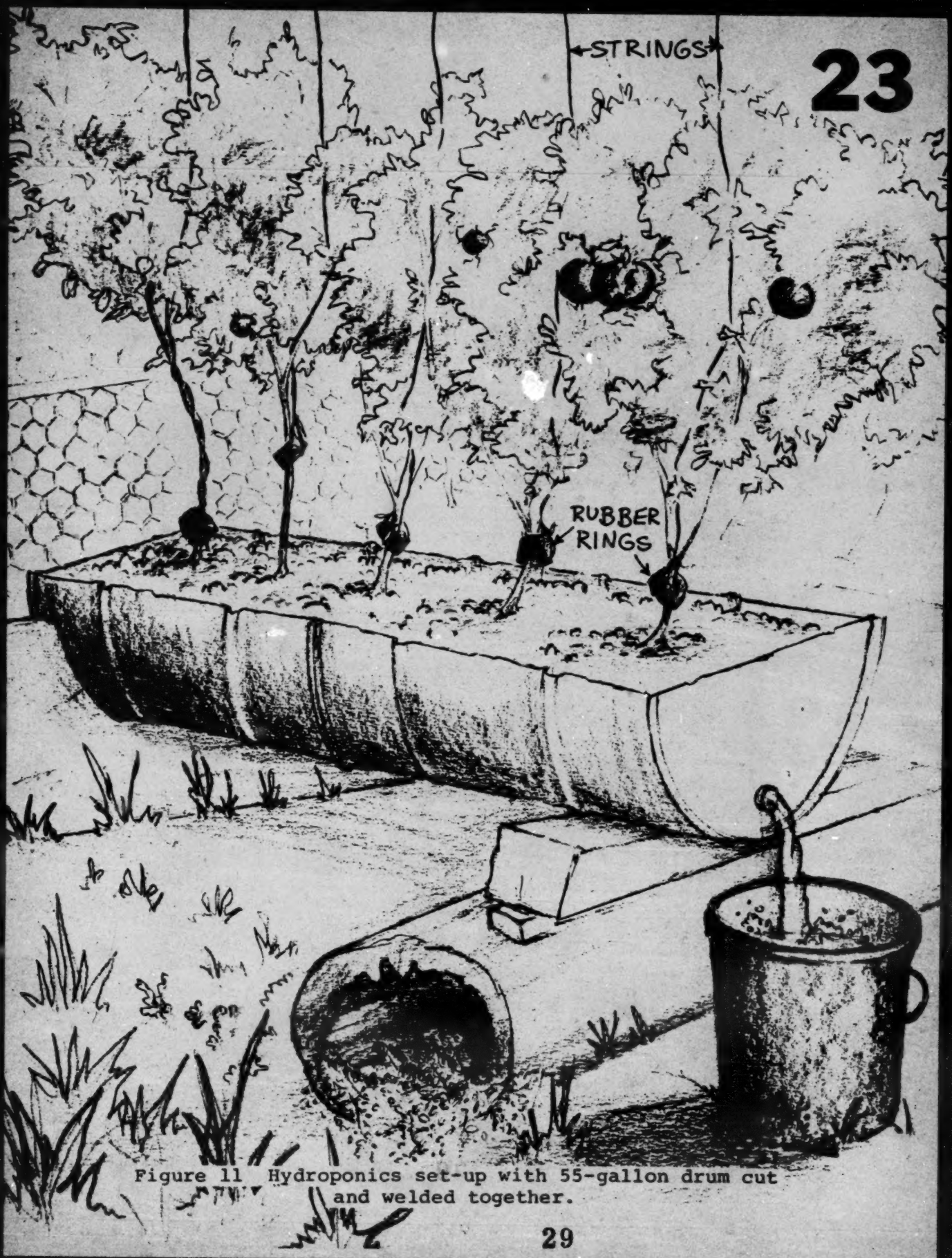

Figure 11 Hydroponics set-up with 55-gallon drum cut and welded together.

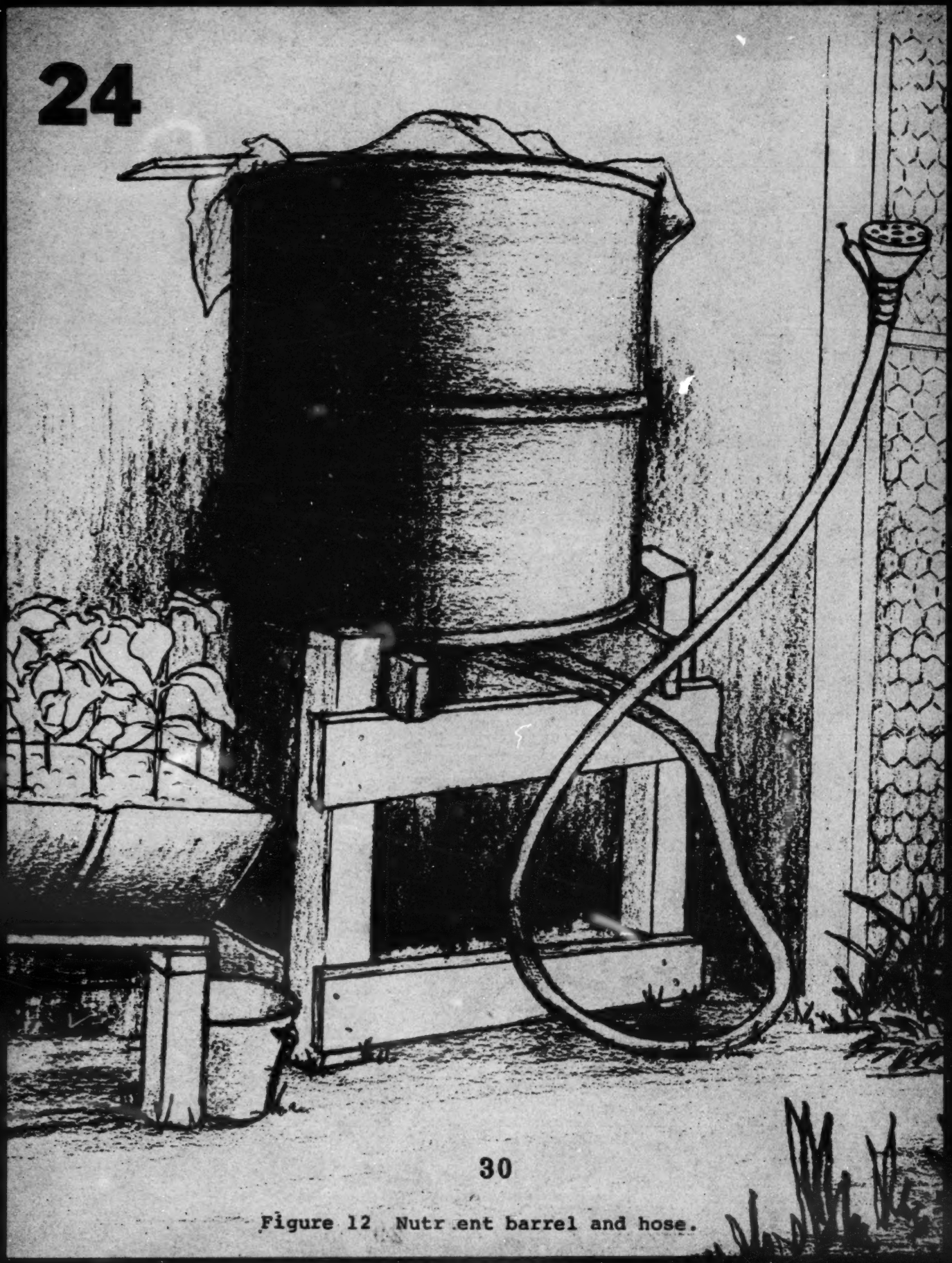

Figure 12 Nutr ent barrel and hose.

by staking or tying while others do not. Careful planning then becomes important to avoid crowding, or one plant being shaded by another. Tomato plants, for example, need at least a square foot of surface space each and grow quite tall while lettuce takes only half as much space and is a low-growing plant. Vine crops such as cucumbers, squash, and melons also need support. This is given by running a string from the base of the plant to a framework above. The string is tied to the base of the plant by a plastic or rubber ring made for the purpose. (See Figure 12). As the plant grows upward the string is twisted around the stalk and does not get in the way of its growth.

The growing medium should be moist at all times with the liquid nutrient. Too much nutrient will cause rank growth (much stem and leaf growth), and fruit production will be less. The best method is to follow directions and watch the plants carefully for normal growth. The dosages suggested by the manufacturer are made larger than necessary so as to sell as much of the product as possible. It may be necessary to reduce the amount used but it should be done carefully. Careful watching for any change in plant growth will usually tell the grower which way to go.

Insects can be controlled by spraying with "Diazinon" or some other effective product, depending on the kind of damage. Most sprays are made to kill only certain kinds of insects. When fruit is nearly ready to eat a product such as "Sevin" is good for killing most insects. The waiting period between spraying and harvest is only one day for most garden products that have been sprayed with "Sevin". The local Department of Agriculture has all the latest information for insect control on Guam.

Pruning (reducing the size) or suckering (removing excess branches) plants is important in hydroponics culture. The number and quality of fruits can be made better by careful control of the number and position of new fruit-bearing branches. Some growers suggest removal of the first flowers to appear. The idea is to sacrifice the first fruits for a stronger plant.

To get started in hydroponics the following activities are recommended:

1. Find out where the commercial growers are located on the Island and observe them carefully to see "how it's done". Then adapt their basic plan to your own use.

2. Talk to the people at the Department of Agriculture for suggestions on plant varieties and insect control.

3. Keep careful records.
   a. How long do the seeds take to germinate?

   b. How long does it take the plant to start producing?

   c. What is the yield per plant? Find out what to expect and try to improve the yield by varying the feeding.

   d. Experiment with varieties, spacing, amount of light and nutrient control. This is a matter of comparing one bed with another and keeping carefully written records.

Activities:

1. Experiment in a small way, with the teacher's help, on the school garden plot. Grow a variety of vegetables in small containers to show how hydroponic culture works.

2. Visit the hydroponics plants on the Island as a class field trip. Question the managers carefully and explain what you're trying to do. They will be glad to help.

3. Try home projects. Each student should submit a statement on how he intends to set up his project and what is to be grown. He should work with a time schedule. Progress reports should be discussed by the class. As new ideas come out students will learn from each other.

VI. Plant Reproduction

A. Methods of Vegetative Reproduction:

1. Cuttings

In vegetative reproduction new plants are produced from the stems, roots or leaves of parent plants. The main advantage is the time saved in growing new plants. Starting plants from seed is a long process. A seed is the result of sexual reproduction and the progeny (off-spring) may be very different from the parents. Herbaceous (soft-stemmed) plants such as tomatoes, eggplants, and cucumbers are grown from seeds. They can be bought on the Island and produce fruit in a few months. Other herbaceous plants like banana, taro and yam, and woody plants are usually grown vegetatively from cuttings of plant parts.

Cuttings or scions are parts taken from the stem or branch. These should be from young wood near the ends of branches or the tip of the stem. Root cuttings are taken from a section of the root, or, as in yams, a section of the tuber containing a bud.

Cuttings should be rooted in sand and then transplanted into soil when roots develop. The plants should be watered heavily every day. For best results rooting compounds (commercial products) should be used.

Another method for starting new plants is to cover a section of stem with soil so that roots will form at the nodes (joints). Plants with trailing stems like kadagan or any of the succulent plants respond nicely to this method.

2. Air Layering

This method is often used for starting new breadfruit plants. Instead of bending a branch down to be covered with soil, a short length of bark is taken off from a small branch and the exposed wood is then wrapped tightly with lumot (moss). Best results come from a young branch of about 2-3 cm in diameter. Two cuts are made 7-8 cm apart, and the bark is peeled off and the bare wood is wrapped tightly with wet moss. The moss is then covered with aluminum foil (or plastic) to hold in moisture.

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Some growers leave a small strip of bark for food supply to the developing roots; this is not really necessary but may be a good practice. The water-carrying cells are not damaged by taking off the bark so the leaves at the end of the branch can continue the food-making process. The food made in the leaves will help roots to form under the moss. Roots will form in about three weeks and the branch can then be cut off and planted in soil. (Caution: To prevent roots from drying out the foil or plastic should be taken off at the last minute before the planting.)

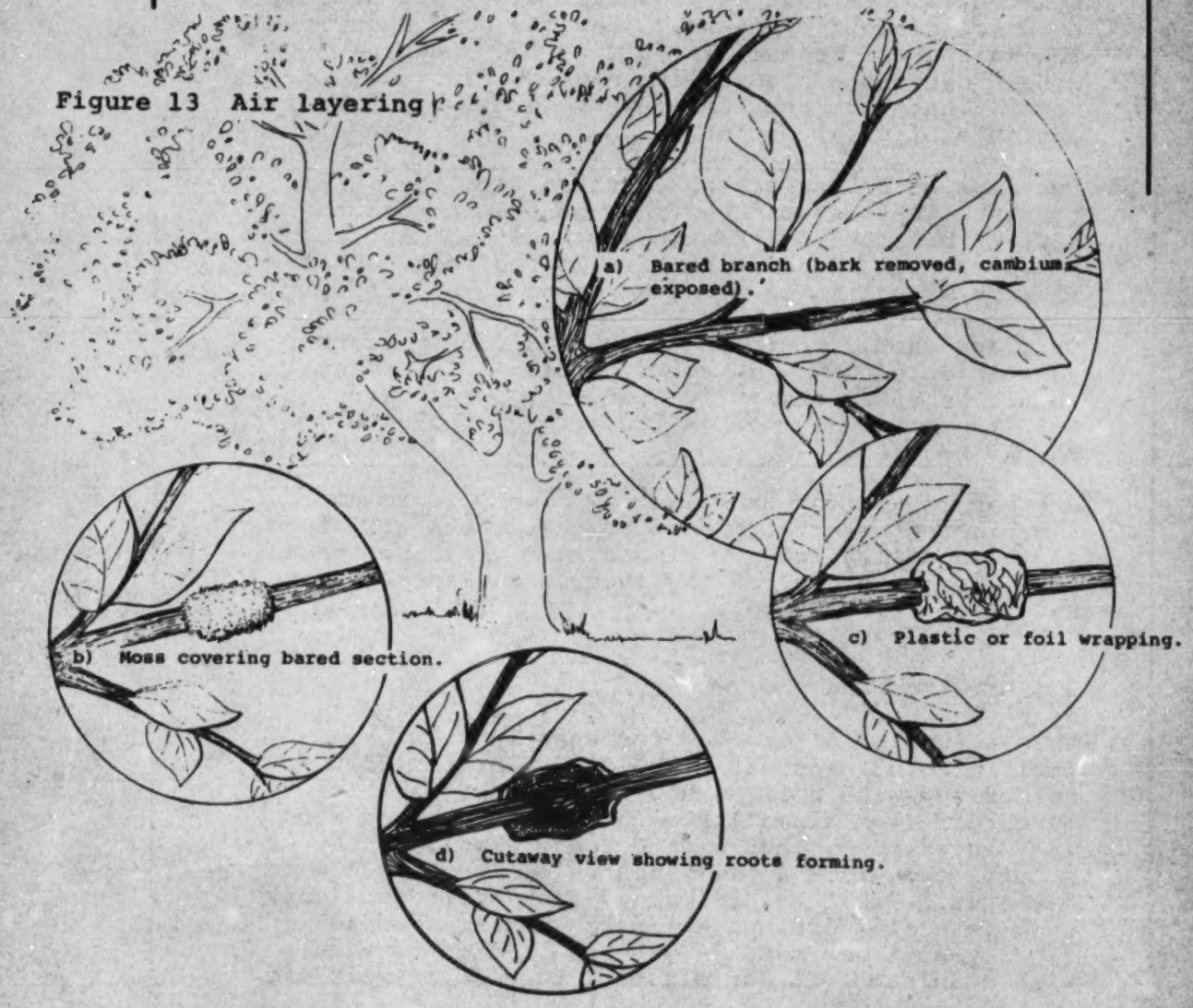
a) Bared branch (bark removed, cambium exposed).
b) Moss covering bared section.
c) Plastic or foil wrapping.
d) Cutaway view showing roots forming.

Figure 13 Air layering

3. Grafting and Budding

Any one of several methods can be used successfully in grafting (see illustrations). The important thing to remember is that the conducting tissues (water-and-food-carrying tissues) must match so that the flow of water and food passes through the graft. The advantage of this type of vegetative reproduction is that buds or cuttings from a plant that you want can be grafted onto an already healthy root stalk. Most woody plants can be grafted with success and many people on Guam use this method.

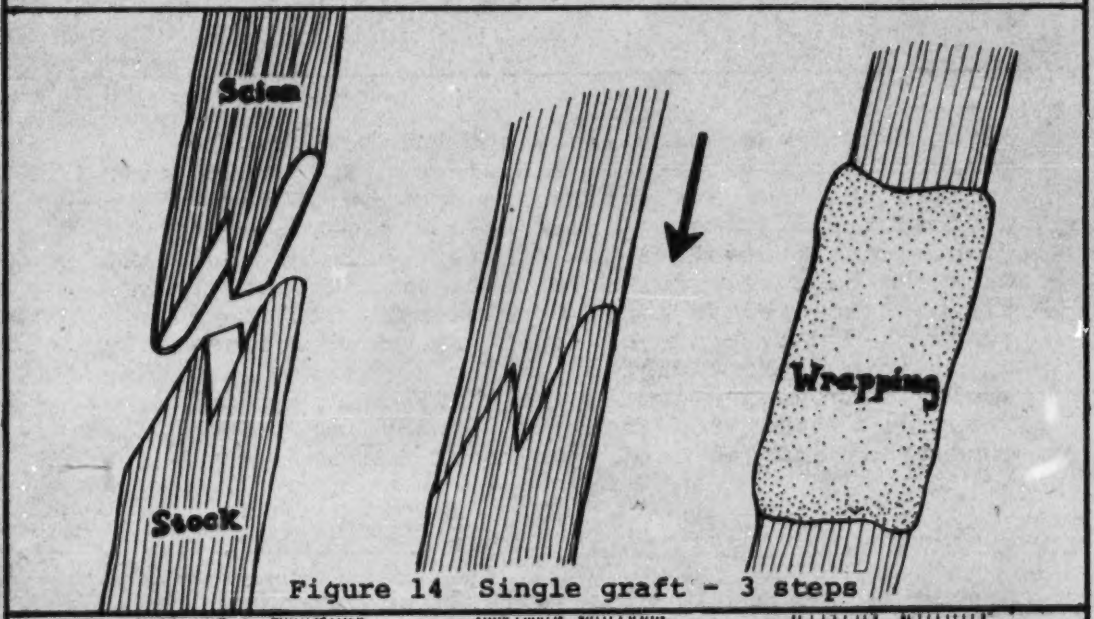

Figure 14 Single graft - 3 steps

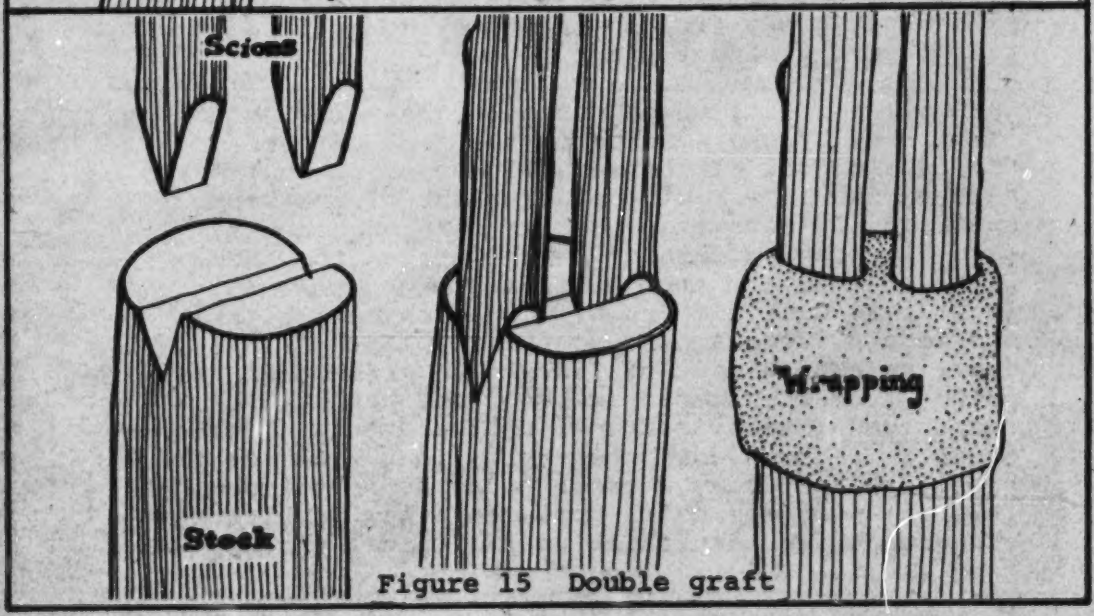

Figure 15 Double graft

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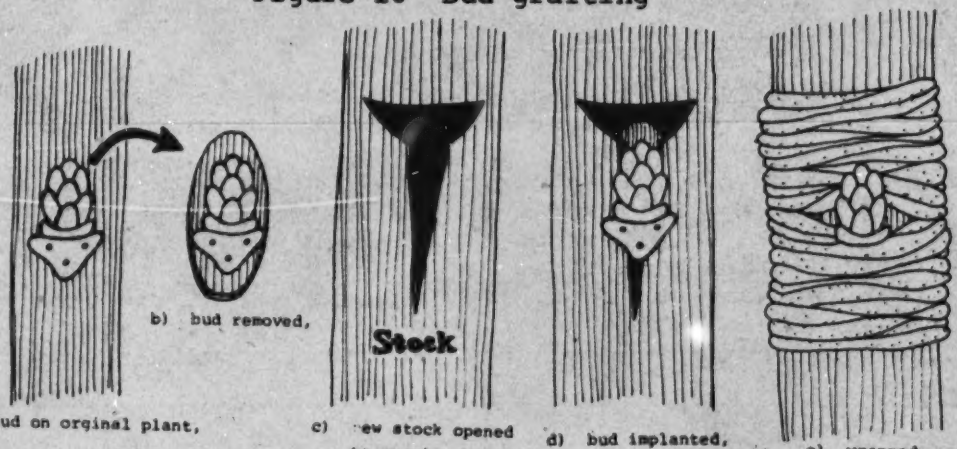
Figure 16 Bud grafting



As an example Bougainvilleas and hibiscus can be grafted with a variety of flower colors. Fruit trees (within the same family) can be grown with several different varieties of fruit on the same tree. Plants that are native to a certain part of the world make the best rootstalks for that area because they are best adapted to local conditions. Cultivated roses and many kinds of fruit are grown successfully by grafting. Most grafted plants do better than they would if they were growing on their own rootstalks. The idea is that the stock is already adapted to local conditions and can readily support a scion.

B. Sexual Reproduction in Plants

A seed is the result of sexual reproduction, and the plant that grows from the seed may be quite different from the parent plant.

The pollen grain, which contains the male sex cell, is carried by the wind or on the feet of bees to the female part of the same flower or to the female part on the flower of another plant of the same species. In some cases, as in corn or coconut, male flowers and female flowers are on the same plant. In others such as fadang, and papaya (usually), male flowers grow only on male plants and female flowers only on female plants. Whatever the arrangement of flowering parts, once the pollen from the stamen (male organ) has landed on the stigma (sticky surface) of the pistil (female organ), it grows down the style (long neck) of the pistil to the ovary where the egg is fertilized. This union of sex cells produces a new combination of genes which results in an individual that is

different from either parent. In this sense, sexual reproduction in plants is exactly the same as it is in animals.

Self-pollination is the transfer of pollen from the male organ to the female organ of the same plant. Cross-pollination is the transfer of pollen from the male organ on one plant to the female organ on another plant of the same species. Controlled pollination can be done by making this transfer by hand so that parentage is known. This method is used in the production of hybrid plants. It involves covering (with a sac) female flowers to insure that pollen from another plant is not allowed to fall on the pistil. When the pollen is ready for transfer, the sac is removed long enough to make the transfer and then replaced.

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APPENDIX

School Nursery

A small nursery on the school property would be a great help in the teaching of gardening. It would provide a place to demonstrate various techniques and for student projects.

Recommended:

1. A fenced area (½ acre if possible).
2. Lath house with plastic roof (4m x 8m) with raised (elongated flats).
3. Source of water.
4. Source of soil.
5. Garden tools, hoses, pails, sprinklers, hand sprayer.
6. Budget for purchase of seeds, fertilizers, sprays, peat moss, etc.

Initial cost - approximately $300.00

Annual budget - $50.00

SUGGESTED FARM & GARDEN EQUIPMENT LIST:

Containers for holding soil: baskets, pails, boxes, plastic bags, etc.

Container for hydroponics: 55-gallon drum or other.

Oven or soil heater or formaldehyde or household bleach (for sterilizing soil).

Pebbles (marbles, shells....).

Growing medium for hydroponics (sand, peat, gravel, coconut husks, cork sheets).

Plastic for hydroponics and lath house.

Chicken or other wire for fence.

Scrap lumber for framework, seed flats, stakes, etc.

String and rubber rings.

Foil or plastic (to wrap air layerings).

Garden tools, such as hoses, pails, sprinklers, hand sprayer, rake, shovel, hoe, trowel, shears, knife, machete, fusinos, etc.

Spotting boards (students with pencils).

Soil - could be synthetic.

Plant food or fertilizers (e.g. well-rotted chicken manure)

Peat pellets or peat pots or jiffy cubes.

Compost pile: manure——chicken, duck, pig, cow, etc.—— grass, wood, small branches, leaves, paper, straw, etc. Also need low walls or framework——perhaps some corrugated metal or plastic, boards or logs.

Peat moss, coconut fibers (husks).

Lumot (moss).

Hyponex plant food.

Diazinon, or Sevin, or other spray.

Rooting compounds.